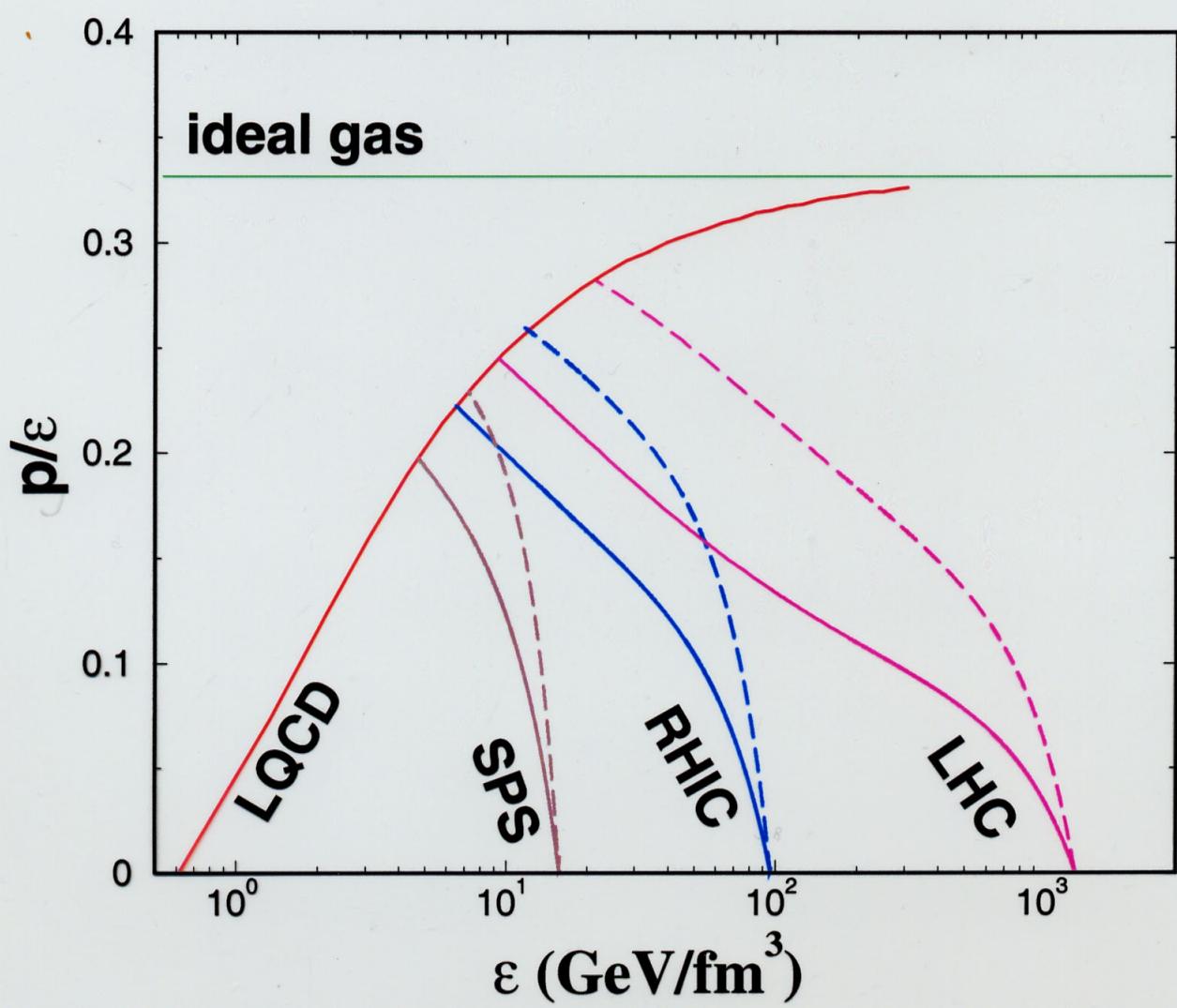


Degrees of Freedom and the "Deconfining Phase Transition"

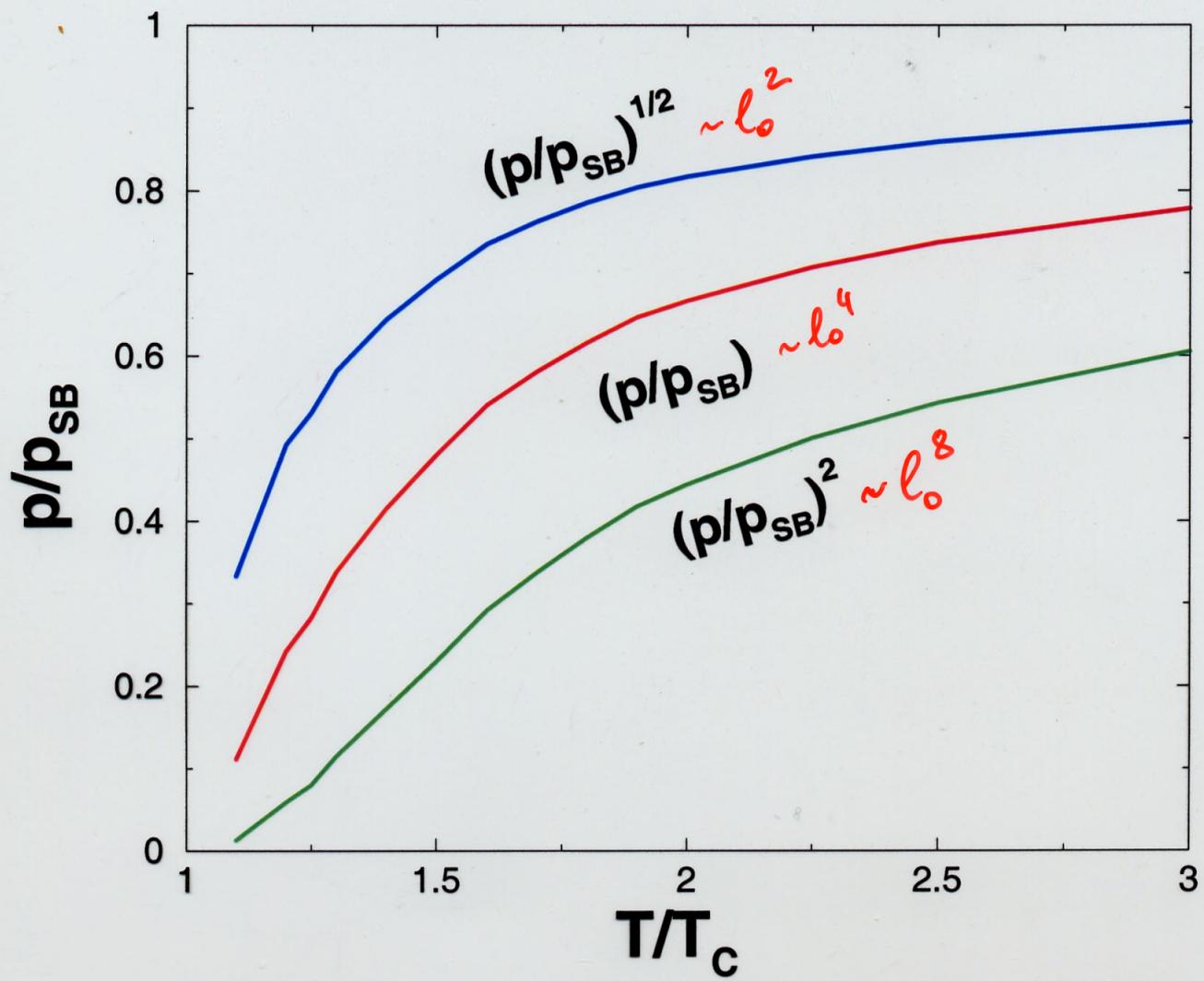
A.D. + Rob Pisarski
hep-ph/0106176

- A fundamental prediction from the Lattice:
for 3 colors, QCD or $SU(3)$ gauge theory
is not an ideal gas for $T/T_c \sim 1-3$.
 $P_{QCD}(T) \neq P_{SB}(T)$
- Can it be seen from HIC @ RHIC??
Observables ...
(HBT (π, k): strong 1st- O p.t. ??)
(flow analysis: Teaney + Shuryak)
- Energy loss
- Continuum Dileptons + Photons
- ⋮
- Parton Cascade Scattering Rates

A.D. + Miklos Gyulassy
hep-ph/0006257



pressure for $SU(3)$ LGT
CP-PACS, hep-lat/0105012



$$N_f = 0 \longrightarrow N_f > 0$$

T_c changes: $0.63\sqrt{\sigma(0)} \rightarrow 0.41\sqrt{\sigma(0)}$

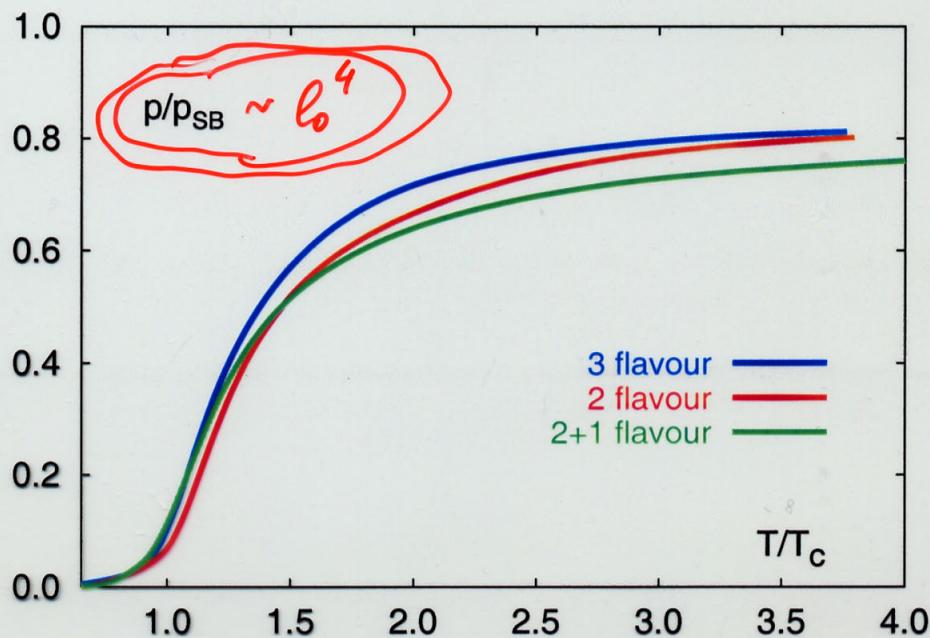
P_{SB}/T^4 changes: $\frac{16\pi^2}{90} \rightarrow \frac{37\pi^2}{90} (N_f=2), \frac{47.5\pi^2}{90} (N_f=2+1)$

but

$$P(T/T_c) / P_{SB} \approx \text{universal}$$

and

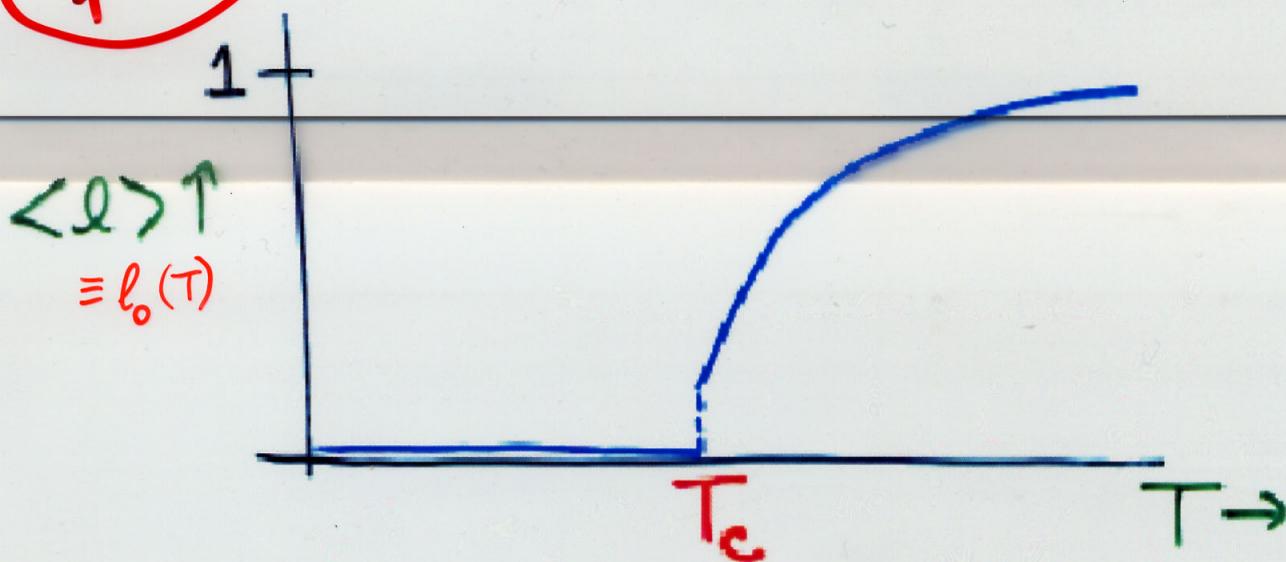
$P \approx 0$ for $T < T_c$



Karsch, Laermann, Peikert
hep-lat/0002003

$N_f = 0$

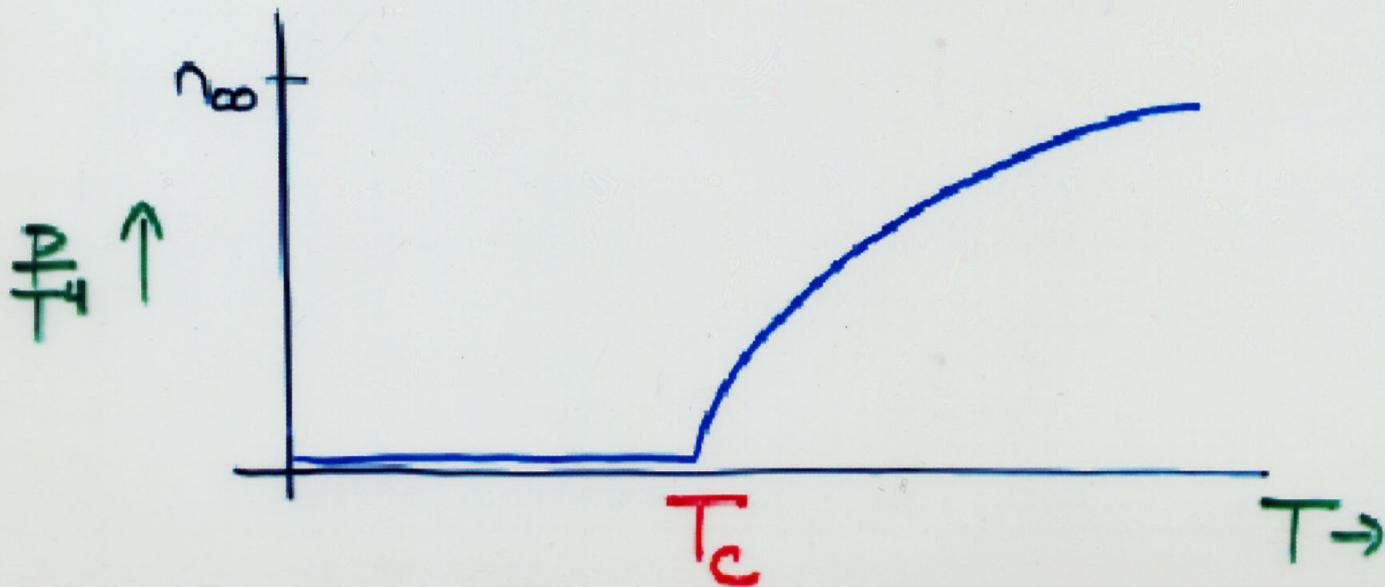
Polyakov Loops & pressure



$$V = (2b_2 |l|^2 + (|l|^2)^2) b_4 T^4$$

l dim. less \Rightarrow overall T^4 !

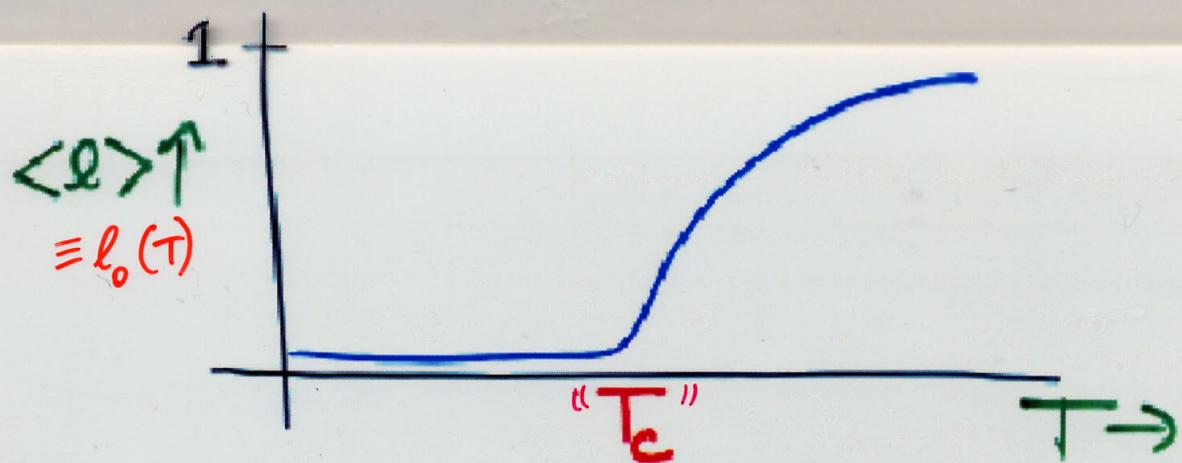
+ $b_3 (l^3 + \frac{1}{l} \dots)$ nearly 2nd order $\Rightarrow b_3$ small



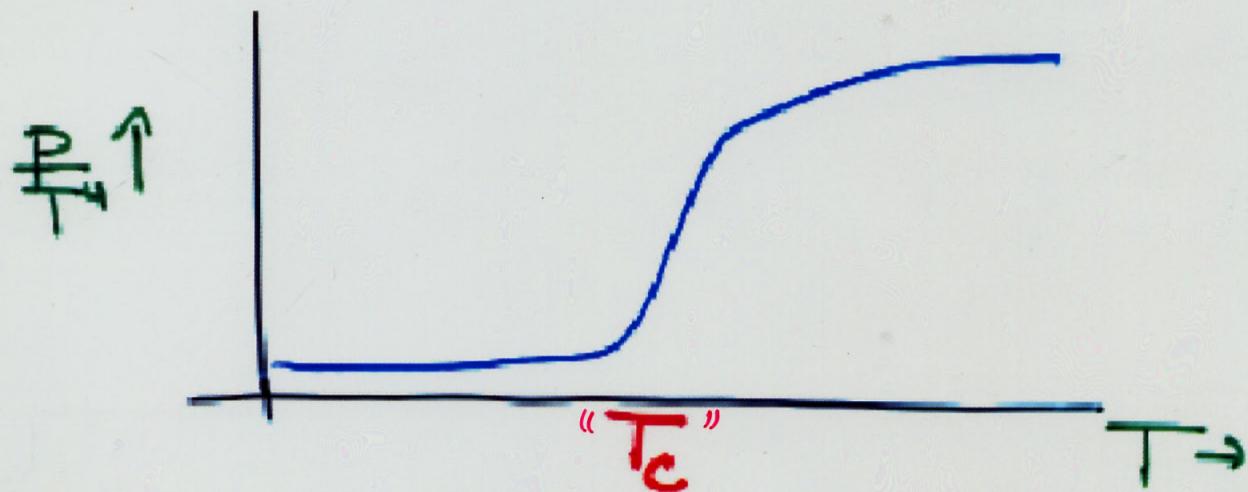
Rob Pisarski, PRD 62 (2000)

$$N_f \neq 0$$

$$\langle l \rangle \neq 0 \quad \forall T$$



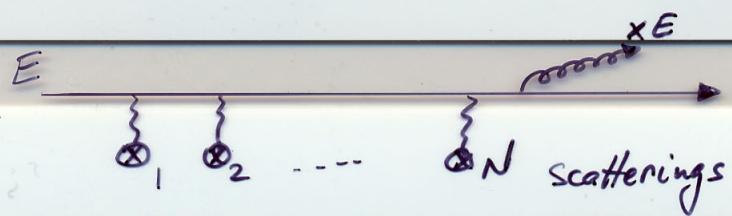
$$V = (b_1(l^*) + 2b_2|l|^2 + (|l|^2)^2) b_4 T^4 + l^3 \dots$$



P small @ $T < T_c \Rightarrow P$ dominated by $V(l)$

{ increases by -? - 5 as $T \rightarrow T_c$

Radiative Energy Loss:



$$E_{LPM} = \lambda m_e^2$$

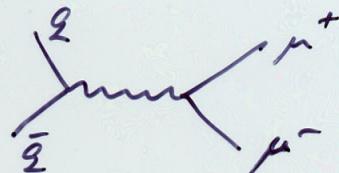
$$m_e^2 \equiv V''(l_0) \sim l_0^{-2}$$

1) $\frac{E}{E_{LPM}} < N^2 :$ $- \frac{dE}{dz} \sim \frac{\alpha_s}{\pi} \frac{E}{\lambda} \sim l_0^{-2}$

2) $\frac{E}{E_{LPM}} > N^2 :$ $- \frac{dE}{dz} \sim \frac{\alpha_s}{\pi} m_e^2 \frac{L}{\lambda} \sim l_0^{-4}$

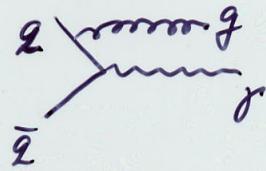
Continuum "Thermal" Dileptons:

$$\frac{dN^{e^+ e^-}}{d^4x} \sim \left(\frac{P_{QCD}}{P_{SB}} \right)^2 \sim l_0^{-8}$$

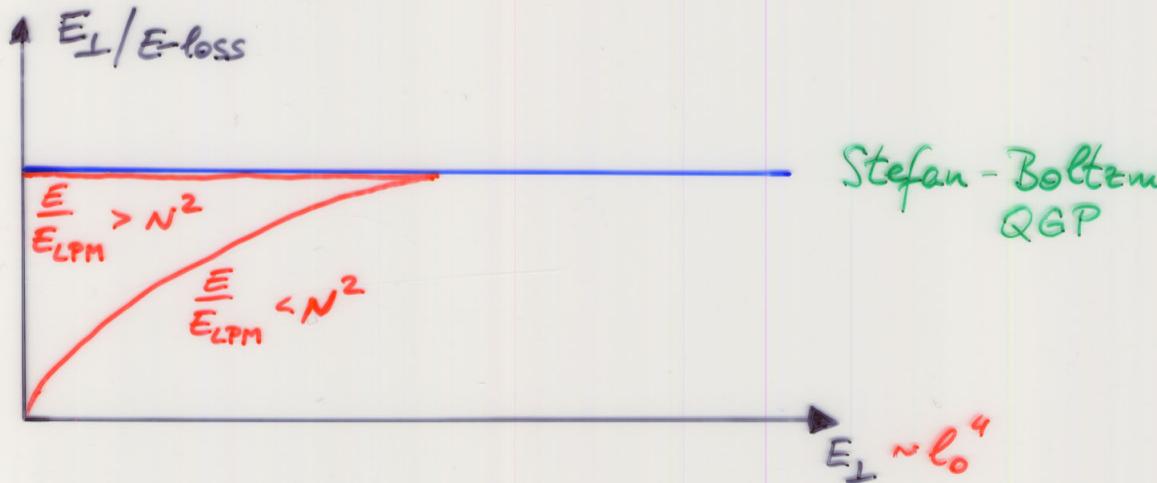


... Photons:

$$\frac{dN^\gamma}{d^4x} \sim \left(\frac{P_{QCD}}{P_{SB}} \right)^{3/2} \sim l_0^{-6} (?)$$



Is Energy Loss proportional to Energy Density?



→ Is there a nonlinear dependence of E-loss on E_L ??
Is it proportional to $\sqrt{\frac{P_{QCD}}{P_{SB}}}$? ? ? ?
from the Lattice with 3 colors

There might be a transition from

$$\text{E-loss} \sim \sqrt{E_L}$$

(similar to Bjorken '82 prediction for elastic E-loss)

to

$$\text{E-loss} \sim E_L$$

(Stefan - Boltzmann QGP
Gyulassy / Vitev et al.)

BDMPS
Wiedemann
Zakharov
:

Transport Opacity $\chi \sim \sigma_t \frac{dN}{dy}$

Transport X section $\sigma_t \sim \frac{\alpha^2}{s} \log \frac{s}{m_e^2}$ (for $\frac{m_e^2}{s} \approx 1$)

Extreme Perturbative QGP: $m_e = 2 m_{D\bar{e}} \sim \sqrt{\pi T}$

but smaller at $T/T_c = 1 \dots 3$!

As before, $\frac{dN}{dy} \sim l_0^{-4}$

mass of Polyakov Loop $m_e^2 \sim l_0^{-2}$

MPC v2, Denes Molnar

nucl-th/0104073

